for wholesale trade companies, electrical repair shops, manufacturers of electronic components, and the telecommunications industry. About 1 in 10 repairers was self-employed.

Training, Other Qualifications, and Advancement
Knowledge of electronics is necessary for employment as an electronics repairer of commercial and industrial equipment. Many applicants gain this training through programs lasting 1 to 2 years at vocational schools and community colleges. Entry level repairers may work closely with more experienced technicians who provide technical guidance.

Repairers should have good eyesight and color perception in order to work with the intricate components used in electronic equipment. Field technicians work closely with customers and should have good communications skills and a neat appearance. Employers may also require that field technicians have a driver's license.

The International Society of Certified Electronics Technicians (ISCET) and the Electronics Technicians Association (ETA) administer certification programs for electronics technicians. Repairers may specialize—in industrial electronics, for example. To receive certification, repairers must pass qualifying exams corresponding to their level of training and experience. Both programs offer associate certifications to entry level repairers.

Experienced repairers with advanced training may become specialists or troubleshooters who help other repairers diagnose difficult problems. Others may move into higher paying jobs, such as skilled craft positions. Workers with leadership ability may become supervisors of other repairers. Some experienced workers open their own repair shops.

Job Outlook
Job opportunities should be best for applicants with a thorough knowledge of electronics, as well as electronics repair experience. Employment of electronics repairers of commercial and industrial equipment is expected to grow about as fast as the average for all occupations through 2008. Growth will be concentrated in private industry, where the increasing use of equipment will create new jobs for repairers. Employment of repairers in the Federal government will decline, however, as the Defense Department increases its use of outside contractors to provide repair services. In addition to employment growth, many job openings should result from the need to replace workers who transfer to other occupations or leave the labor force.

The use of commercial and industrial electronic equipment will become more widespread, as businesses strive to lower costs by increasing automation. Companies will install electronic controls, robots, sensors, and other equipment, to automate processes such as assembly and testing. As prices decline, applications will be found across a number of industries, including services, utilities, and construction, as well as manufacturing. Improved equipment reliability should not constrain employment growth; companies will increasingly rely on repairers, because any malfunction that idles commercial and industrial equipment is costly.

Earnings
Median hourly earnings of electronics repairers of commercial and industrial equipment were $17.11 in 1998. The middle 50 percent earned between $13.37 and $20.93. The lowest 10 percent earned less than $10.22 and the highest 10 percent earned more than $23.81. Median hourly earnings in the industries employing the largest numbers of electronics repairers of commercial and industrial equipment in 1997 are shown below:

Federal Government	$18.00
Professional and commercial equipment	15.60
Electrical repair shops	12.10

Related Occupations
Workers in other occupations who repair and maintain electronic equipment include broadcast and sound technicians; computer, automated teller, and office machine repairers; electronic home entertainment equipment repairers; and telecommunications equipment mechanics, installers, and repairers. Industrial machinery repairers and millwrights also install, maintain, and repair industrial machinery.

Sources of Additional Information
For information on careers and certification, contact:
☛ The International Society of Certified Electronics Technicians, 2708 West Berry St., Fort Worth, TX 76109. Internet: **http://www.iscet.org**
☛ Electronics Technicians Association, 602 North Jackson, Greencastle, IN 46135. Internet: **http://www.eta-sda.com**

Telecommunications Equipment Mechanics, Installers, and Repairers

(O*NET 85502, 85505, 85508, 85514, 85599A, 85599B, 85599C, and 85726)

Significant Points

- Growing demand for sophisticated telecommunications equipment will be offset by improved equipment reliability, resulting in average employment growth.
- Opportunities should be best for applicants with electronics training and computer skills.
- Weekend and holiday hours are common; repairers may be on call around the clock, in case of emergencies.

Nature of the Work
Telephones and radios depend on a variety of equipment to transmit communications signals. Electronic switches route telephone signals to their destinations. Switchboards direct telephone calls within a single location or organization. Radio transmitters and receivers relay signals from wireless phones and radios to their destinations. Newer telecommunications equipment is computerized and can communicate a variety of information, including data, graphics, and video. The workers who set up and maintain this sophisticated equipment are telecommunications equipment mechanics, installers, and repairers.

Central office installers set up switches, cables, and other equipment in telephone central offices. These locations are the hubs of a telephone network—they contain the switches that route telephone calls to their destinations. *PBX installers* set up private branch exchange (PBX) switchboards. This equipment relays incoming, outgoing, and interoffice calls for a single location or organization. To install switches and switchboards, installers first connect the equipment to power lines and communications cables and install frames and supports. They test the connections to insure that adequate power is available and that the communication links function. They also install equipment such as power systems, alarms, and telephone sets. New switches and switchboards are computerized; workers install software or may program the equipment to provide specific features. For example, as a cost-cutting feature, an installer may program a PBX switchboard to route calls over different lines at different times of the day. However, other workers, such as *network technicians* or *telecommunications specialists*, rather than installers generally handle complex programming. (The work of other computer specialists is described in the *Handbook* statement on computer systems analysts, engineers and scientists.) Finally, the installer performs tests to verify that the newly installed equipment functions properly.

The increasing reliability of telephone switches and switchboards has simplified maintenance. New telephone switches are self-monitoring and alert repairers to malfunctions. Some switches allow repairers to diagnose and correct problems from remote locations. When faced with a malfunction, the repairer may refer to manufacturers' manuals that provide maintenance instructions. PBX repairers determine if the problem is located within the PBX system, or if it originates in the

telephone lines maintained by the local phone company. To fix the equipment, repairers may use small hand tools, including pliers and screwdrivers to replace defective components, such as circuit boards, fuses, or wiring. They may also install updated software or programs that maintain existing software.

Radio mechanics install and maintain radio transmitting and receiving equipment. This includes stationary equipment mounted on transmission towers and mobile equipment, such as radio communications systems in service and emergency vehicles. Newer radio equipment is also self-monitoring and may alert mechanics to potential malfunctions. When malfunctions occur, these mechanics examine equipment for damaged components and loose or broken wires. They use electrical measuring instruments to monitor signal strength, transmission capacity, interference, and signal delay. Additionally, they use hand tools to replace defective components and parts and adjust equipment, so it performs within required specifications.

Station installers and repairers—known commonly as *telephone installers and repairers*—install and repair telephone wiring and equipment on customers' premises. They install telephone service by connecting customers' telephone wires to outside service lines. These lines run on telephone poles or in underground conduits; the installer may climb poles or ladders, to make the connections. Once the telephone is connected, the line is tested, to insure that it receives a dial tone. When a maintenance problem occurs, repairers test the customers' lines, to determine if the problem is located in the customers' premises or in the outside service lines. When on-site procedures fail to resolve installation or maintenance problems, repairers may request support from their technical service center.

Other telecommunications equipment mechanics, installers, and repairers include workers who install and maintain telegraphic equipment and workers who connect wires from telephone lines to distributing frames in telephone company central offices.

Working Conditions

Telecommunications equipment mechanics, installers, and repairers generally work in clean, well-lighted, air-conditioned surroundings, such as a telephone company's central office, a customer's PBX location, or an electronic repair shop or service center. Telephone installers and repairers work on rooftops, ladders, and telephone poles. Radio mechanics may maintain equipment located on the tops of transmissions towers. While working outdoors, these workers are subject to a variety of weather conditions.

Nearly all telecommunications equipment mechanics, installers, and repairers work full time. Many work regular business hours, to meet the demand for repair services during the workday. Schedules are more irregular at companies that need repair services 24 hours a day or where installation and maintenance must take place after business hours. At these locations, mechanics work a variety of shifts including weekend and holiday hours. Repairers may be on call around the clock, in case of emergencies and may have to work overtime.

The work of most repairers involves lifting, reaching, stooping, crouching, and crawling. Adherence to safety precautions is important to guard against work hazards. These hazards include falls, minor burns, electrical shock, and contact with hazardous materials.

Telecommunications equipment mechanics, installers, and repairers may work outdoors.

Employment

Telecommunications equipment mechanics, installers, and repairers held about 125,000 jobs in 1998. Most worked for telephone communications companies. Many radio mechanics worked in electrical repair shops. The distribution of employment by occupation was as follows.

Central office and PBX installers and repairers	44,000
Station installers and repairers, telephone	24,000
Radio mechanics	7,000
All other telecommunications equipment mechanics, installers, and repairers	49,000

Training, Other Qualifications, and Advancement

Most employers seek applicants with post secondary training in electronics; familiarity with computers is also important. Training sources include 2- and 4-year college programs in electronics or communications, trade schools, and training provided by equipment and software manufacturers. Military experience with communications equipment is highly valued by many employers.

Newly hired mechanics usually receive some training from their employers. This may include formal classroom training in electronics, communications systems, or software and informal, hands-on training with communications equipment. Large companies may send mechanics to outside training sessions, to keep these employees informed of new equipment and service procedures. As networks have become more sophisticated—often including equipment from a variety of companies—the knowledge needed for installation and maintenance also has increased.

Mechanics must be able to distinguish colors, because wires are color-coded; they must also be able to hear distinctions in the various tones on a telephone system. For positions that require climbing poles and towers, workers must be in good physical shape. Repairers who handle assignments alone at a customer site must be able to work without close supervision. For workers who frequently contact customers, a pleasant personality, neat appearance, and good communications skills are also important.

Experienced mechanics with advanced training may become specialists or troubleshooters who help other repairers diagnose difficult problems, or work with engineers in designing equipment and developing maintenance procedures. Because of their familiarity with equipment, repairers are particularly well qualified to become manufacturers' sales workers. Workers with leadership ability also may become maintenance supervisors or service managers. Some experienced workers open their own repair services or shops or become wholesalers or retailers of electronic equipment.

Job Outlook

Employment of telecommunications equipment mechanics, installers, and repairers is expected to grow about as fast as the average for all occupations through 2008. Growth will be driven by the increasing demand for sophisticated telecommunications equipment. Although the need for installation work will grow as companies seek to upgrade their telecommunications networks, the need for maintenance work should decline, because of increasingly reliable self-monitoring and self-diagnosing equipment. Opportunities should be best for applicants with electronics training and computer skills.

Projected employment growth varies by occupation. Employment of central office and PBX installers and repairers is expected to grow faster than average, as the growing popularity of the Internet continues to place new demand on telecommunications networks. Conventional switches designed to handle voice communications will need to be replaced and upgraded with equipment that can communicate more complex information, such as data, videos, and graphics. Switches that can quickly relay both voice and data communications will become a necessity. Whereas increased reliability and automation of switching equipment will constrain employment growth, these effects will be offset by the strong demand for installation and upgrading of switching equipment.

Despite some demand for mechanics in the rapidly growing wireless telecommunication sector to build networks of receivers, transmitters, and other equipment, the employment of radio mechanics is projected to decline. The replacement of two-way radio systems by wireless systems, especially in service vehicles, has eliminated the need in many companies for on-site radio mechanics. The increased reliability of wireless equipment and the use of self-monitoring systems will continue to lessen this need.

Employment of station installers and repairers is also expected to decline. Pre-wired buildings and the increasing reliability of telephone equipment will decrease the need for installation and maintenance of customers' telephones. The popularity of the Internet may increase employment over the next few years, as additional households request the installation of second telephone lines. However, this should be offset by the deployment of new technologies, such as digital subscriber lines, which allow simultaneous voice and data communications, and wireless telecommunications services, which do not require installation.

Earnings

In 1998, median hourly earnings of central office and PBX installers and repairers were $21.00. The middle 50 percent earned between $18.09 and $23.52. The bottom 10 percent earned less than $13.92, whereas the top 10 percent earned more than $25.79. Median hourly earnings in the telephone communications industry were $20.40 in 1997.

Median hourly earnings of radio mechanics in 1998 were $14.71. The middle 50 percent earned between $11.21 and $18.73. The bottom 10 percent earned less than $9.09, whereas the top 10 percent earned more than $23.21.

Median hourly earnings of station installers and repairers in 1998 were $19.06. The middle 50 percent earned between $15.80 and $22.17. The bottom 10 percent earned less than $11.55, whereas the top 10 percent earned more than $24.07. Median hourly earnings were $18.90 in the telephone communications industry in 1997.

Central office installers, central office technicians, PBX installers, and telephone installers and repairers represented by the Communications Workers of America earned between $283 and $996 a week in 1998.

Telephone installers and repairers, represented by the International Brotherhood of Electrical Workers, earned between $12.60 and $22.50 an hour in 1999. Equipment installer technicians represented by the same union earned between $16.70 and $24.80 an hour in 1999.

Related Occupations

Related occupations that work with electronic equipment include broadcast and sound technicians; computer, automated teller, and office machine repairers; electronic home entertainment equipment repairers; and electronics repairers, commercial and industrial equipment. Electronics engineering technicians may also repair electronic equipment, as part of their duties.

Sources of Additional Information

For information on career opportunities, contact:

☛ International Brotherhood of Electrical Workers, Telecommunications Department, 1125 15th St. NW., Room 807, Washington, DC 20005.

☛ Communications Workers of America, 501 3rd St. NW., Washington, DC 20001. Internet: **http://www.cwa-union.org**

For information on the telephone communications industry, contact:

☛ United States Telephone Association, 1401 H St. NW., Suite 600, Washington, DC 20005-2164. Internet: **http://www.usta.org**

Other Mechanics, Installers, and Repairers

Aircraft Mechanics and Service Technicians

(O*NET 85323A, 85323B, 85326, and 85728A)

Significant Points

- The vast majority learn their job in 1 of about 200 trade schools certified by the Federal Aviation Administration.
- On the whole, opportunities should be favorable, but keen competition is likely for the best paying jobs with airlines.

Nature of the Work

To keep aircraft in peak operating condition, aircraft mechanics and service technicians perform scheduled maintenance, make repairs, and complete inspections required by the Federal Aviation Administration (FAA).

Many aircraft mechanics specialize in preventive maintenance. They inspect engines, landing gear, instruments, pressurized sections, accessories—brakes, valves, pumps, and air-conditioning systems, for example—and other parts of the aircraft and do the necessary maintenance and replacement of parts. Inspections take place following a schedule based on the number of hours the aircraft has flown, calendar days, cycles of operation, or a combination of these factors. To examine an engine, aircraft mechanics work through specially designed openings while standing on ladders or scaffolds, or use hoists or lifts to remove the entire engine from the craft. After taking an engine apart, mechanics use precision instruments to measure parts for wear and use x-ray and magnetic inspection equipment to check for invisible cracks. Worn or defective parts are repaired or replaced. They may also repair sheet metal or composite surfaces, measure the tension of control cables, and check for corrosion, distortion, and cracks in the fuselage, wings, and tail. After completing all repairs, mechanics must test the equipment to ensure that it works properly.

Mechanics specializing in repair work rely on the pilot's description of a problem to find and fix faulty equipment. For example, during a preflight check, a pilot may discover that the aircraft's fuel gauge does not work. To solve the problem, mechanics may troubleshoot the electrical system, using electrical test equipment to make sure no wires are broken or shorted out and replace any defective electrical or electronic components. Mechanics work as fast as safety permits, so the aircraft can be put back into service quickly.

Large, sophisticated planes are equipped with aircraft monitoring systems, consisting of electronic boxes and consoles that monitor the aircraft's basic operations and provide valuable diagnostic information to the mechanic.

Some mechanics work on one or many different types of aircraft, such as jets, propeller-driven airplanes, and helicopters. Others specialize in one section of a particular type of aircraft, such as the engine, hydraulics, or electrical system. *Powerplant mechanics* are